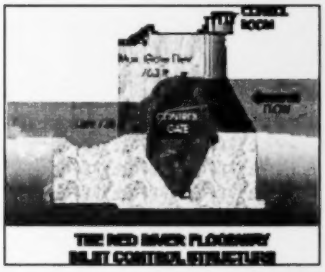
RED RIVER FLOODWAY
OPERATION REPORT

SPRING 2010



THE RED RIVER FLOODWAY INLET CONTROL STRUCTURE

Manitoba Water Stewardship

Manitoba

Manitoba Water Stewardship

RED RIVER FLOODWAY OPERATION REPORT

SPRING 2010

Ecological Services Division
Manitoba Water Stewardship

Printed on Recycled Paper

Manitoba

EXECUTIVE SUMMARY

The Red River spring flood of 2010 was of moderate size, with the natural peak in Winnipeg being the 13th highest since operation of the Red River Floodway first began in 1969. Between its completion in 1968 to 2010, the Floodway has been operated in 27 out of the past 42 years to prevent spring flooding.

During the spring of 2010, the Red River Floodway gates were operated for 600 hours over 25 days beginning at 9:30 AM on March 28 and ending at 9:30 AM on April 22. During this period of operation, 47 discrete gate adjustments were made as required at various times throughout any 24 hour period. In the spring of 2010, 0.5 million acre-feet of water were diverted around the City of Winnipeg with a peak flow of 16,200 cfs.

In spring 2010, operation of the Floodway was successful in protecting the City of Winnipeg while minimizing upstream impacts, through normal operation in accordance with Rule 1 of the Floodway Rules of Operation, which requires the Department of Water Stewardship to maintain natural levels on the Red River at the Floodway inlet. In concert with operation of the Portage Diversion and Shellmouth Reservoir, operation of the Floodway reduced the flood crest in the City of Winnipeg by 4.5 feet.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY i
TABLE OF CONTENTS ii
INTRODUCTION 1
2010 SPRING RUNOFF 1
THE RED RIVER FLOODWAY 2
OPERATION OF THE FLOODWAY IN SPRING 2010 3
CONCLUSIONS 4

TABLES

Table 1: 2010 Spring Floodway Gate Operations

FIGURES

Figure 1: Recorded River Levels at James Avenue 2010
Figure 2: Recorded and Natural Levels at Floodway Entrance 2010

APPENDICES

Appendix A: Red River Floodway Rules of Operation
Appendix B: Computation of Natural Flows and Levels

INTRODUCTION

On April 20, 2005, *The Red River Floodway Act* was proclaimed in force. Subsection 11(1) of this Act states that:

> *"On or before June 30 of any year in which the government operates the floodway during spring flooding to regulate the river level, the director must provide the minister with a report about the operation containing the information the minister requires."*

The following report details operation of the Red River Floodway in the spring runoff period of 2010 as required by clause 11(1) of *The Red River Floodway Act*, and includes the information specified in subsection 3(1) of The Red River Floodway Regulation.

Within this report, all flows and levels are shown in imperial units. Flows can be converted from cubic feet per second (cfs) to cubic metres per second (m^3/s) by dividing by 35.3148. River levels can be converted from feet to metres by dividing by a factor of 3.28084.

Manitoba Water Stewardship gratefully acknowledges Water Survey of Canada for providing the provisional flows used in the report.

2010 SPRING RUNOFF

The 2010 natural spring flood on the Red River at Winnipeg was the 13th largest since operation of major flood control works began in 1969. The flood at Emerson was the 8th largest and at St. Agathe, the 12th largest for the past 100 years of record. The peak flow in the Red River Floodway was the 12th highest on record for the 42 year period since floodway operation began. The recorded peak stage of 18.6 feet at James Avenue in Winnipeg was the 10th highest during this same period.

The 2010 spring flood resulted from above average soil moisture at freeze-up in 2009 combined with well above average snow cover in the United States portion of the Red River basin. Snow cover in the Manitoba portion of the basin was close to average. Spring rainfall was negligible in the Manitoba portion of the basin but a few rain events did occur within the United States portion of the basin.

Snowmelt runoff began before mid-March, aided by a 35 mm rain-on-snow event in the United States portion of the basin on March 9 to 12, 2010. Runoff from the Manitoba portion of the basin was delayed until late March but crests from Manitoba tributaries occurred before the arrival of the crest from the United States, resulting in little additional rise as the crest moved through Manitoba. Crests in Manitoba occurred on April 1 at Emerson and April 6 at the Floodway Inlet. The crest was slightly below the levels of major transportation routes such as PTH 75 and PR 200.

The crest at Winnipeg occurred on April 2 due to relatively high runoff from local tributaries including the Assiniboine River. The crest in the Selkirk area occurred on March 28 due to significant ice jamming. Ice jams produced the highest stages on record in the St. Peters

Road area between Selkirk and Breezy Point. Minor flooding occurred at Petersfield due to Red River ice jams backing water into Netley Creek.

The start of operation of the Red River Floodway gates was delayed because of an ice jam that occurred near Lord Avenue in south Winnipeg beginning on Friday evening March 26. The jam raised river levels in the St. Norbert area almost 4 feet to within 1.5 feet of those water levels experienced in 2009. Approximately 10,000 cubic feet per second of water was flowing into the Red River Floodway on the morning of March 27 even though the floodway gates had not yet been operated. The Lord Avenue ice jam broke at 3:15 PM on March 27 with assistance from the Amphibex.

THE RED RIVER FLOODWAY

Following the historic flood of 1950 in the City of Winnipeg, work began on the design and construction of a series of flood control measures including Shellmouth Reservoir, Portage Diversion, and the Red River Floodway to protect the City from significant flood events. All were intended to be operated in concert to reduce flood flows and thus, minimize flood damages in the City of Winnipeg.

Operation of the floodway is guided by a set of rules (Appendix A) intended to provide balanced flood protection to the City of Winnipeg without artificially affecting properties south or upstream of the inlet. Rule 1 requires that natural levels not be exceeded upstream of the floodway inlet structure as long as water levels within the City of Winnipeg are less than 24.5 James Avenue. The natural water level on the Red River at the Floodway entrance is defined as the water level that would have occurred at this location in the late 1950s if Shellmouth Reservoir, Portage Diversion, Assiniboine River dikes, and the Red River Floodway were not in place.

During the 2010 spring floodway operation, the natural water levels upstream of the inlet were calculated with the relationship developed by Acres Manitoba Limited in 2004 [*"Re-Computation of Natural Water Levels at the Floodway Inlet (Final Report)", April 2004*]. This relationship requires two input values: the natural flow in the Red River downstream of the Assiniboine River (at James Avenue) and the natural flow of the Assiniboine River into the Red River. These data along with the natural and actual water levels on the Red River at the floodway inlet are shown for the 2010 spring flood in Appendix B, Table 2. Real-time water level and flow data to guide the operations are obtained at a number of sites including the Red River at James Avenue or Chief Peguis Bridge, above and below the Inlet Control Structure, floodway channel, Assiniboine River at Headingley, Portage Diversion, Sturgeon Creek, and La Salle River along with estimates of un-gauged flow from small streams or overland runoff in the Winnipeg area.

OPERATION OF THE FLOODWAY IN SPRING 2010

Approximately 6,200 cubic feet per second of water was flowing into the Red River Floodway at 8 AM on March 28, 2010. The Red River Floodway gates were operated at 9:30 AM on Sunday, March 28 in accordance with normal operating procedures to reduce river levels in the City of Winnipeg.

Operation of the floodway during open water in 2010 followed normal protocol and was consistent with experience in past spring floods.

The computation of natural water levels at the inlet control structure requires calculation of the natural flow at James Avenue. Natural flow is determined by adjusting the actual flow for the effects of the flood control works. Under open water conditions, the actual flow is estimated from the discharge rating curve for the Red River at James Avenue using Water Survey of Canada levels collected at station 05OC015.

The Red River at James Avenue reached its crest under open water at 18.5 feet on April 2, while an ice jam was occurring on the Assiniboine River in Winnipeg. The peak recorded level at the floodway entrance (Water Survey of Canada station 05OC026) was 759.09 feet at 12:00 AM on April 4 during open water operation and was 0.41 feet lower than the computed natural peak level of 759.50 feet.

During operation, the floodway gates were adjusted in small increments to follow the natural rise in water levels. This was done to avoid large gate raises that may have caused sudden changes in water levels above and below the floodway control structure. Table 1 lists the gate operations that occurred during operation of the floodway in the spring of 2010. The average gate adjustment was 0.38 feet during the period of time that floodway flows were affected by gate operation.

Red River recorded and natural levels in Winnipeg at James Avenue during the period of operation are shown on Figure 1 and similar levels at the floodway entrance are plotted in Figure 2.

Overall, in the spring of 2010, 0.5 million acre-feet of water was diverted around the City of Winnipeg with a peak flow of 16,200 cfs. The recorded river level at the floodway entrance was maintained an average of 0.51 feet below the computed natural level throughout the 25 days of floodway operation.

CONCLUSIONS

It can be concluded that:

- During the spring of 2010, the Red River Floodway was operated for 600 hours over 25 days and, in combination with other related flood control measures such as operation of the Portage Diversion and storage of flood waters in Shellmouth Reservoir, reduced the flood crest in the City of Winnipeg by 4.5 feet;
- Operation of the Red River Floodway began at 9:30 AM on March 28, 2010, and concluded at 9:30 AM on April 22, 2010. During this period, 47 discrete gate adjustments were made as required and occurred at various times throughout any 24 hour period;
- Throughout its operation in the spring of 2010, recorded water levels upstream of the inlet were, on average, 0.51 feet lower than natural levels;
- The crest at the floodway inlet was 759.09 feet, 0.41 feet lower than the computed natural peak level of 759.50 feet;
- During spring 2010, 0.5 million acre-feet of water were diverted around the City of Winnipeg with a peak flow of 16,200 cfs.

Table 1 –2010 Floodway Gate Operations

Date	Time *	Start of Operation	End of Operation	Date	Time *	Start of Operation	End of Operation
March 28, 2010	9:30 AM	728.00	739.95	April 13, 2010	7:00 PM	740.91	740.72
March 29, 2010	10:10 PM	739.95	740.34	April 14, 2010	12:20 AM	740.72	740.53
March 30, 2010	9:35 AM	740.34	739.57	April 14, 2010	9:20 AM	740.53	740.43
March 31, 2010	10:30 PM	739.57	740.05	April 14, 2010	3:00 PM	740.43	740.14
April 1, 2010	1:10 PM	740.05	740.24	April 14, 2010	10:30 PM	740.14	739.86
April 1, 2010	5:40 PM	740.24	740.72	April 15, 2010	10:30 AM	739.86	739.67
April 2, 2010	12:05 AM	740.72	741.19	April 15, 2010	4:35 PM	739.67	739.29
April 2, 2010	11:30 AM	741.19	742.90	April 16, 2010	1:00 AM	739.29	739.09
April 2, 2010	11:05 PM	742.90	743.38	April 16, 2010	9:20 AM	739.09	738.90
April 3, 2010	2:30 PM	743.38	743.85	April 17, 2010	10:05 AM	738.90	738.62
April 4, 2010	2:00 AM	743.85	743.47	April 17, 2010	4:30 PM	738.62	738.33
April 4, 2010	12:05 PM	743.47	743.00	April 17, 2010	11:00 PM	738.33	738.14
April 4, 2010	10:30 PM	743.00	742.62	April 18, 2010	2:30 PM	738.14	737.85
April 5, 2010	5:30 PM	742.62	743.00	April 18, 2010	10:30 PM	737.85	737.57
April 7, 2010	10:20 PM	743.00	742.81	April 19, 2010	10:40 AM	737.57	737.28
April 8, 2010	11:10 AM	742.81	742.43	April 19, 2010	4:30 PM	737.28	736.90
April 8, 2010	11:00 PM	742.43	742.24	April 20, 2010	12:40 AM	736.90	736.52
April 9, 2010	12:30 PM	742.24	742.05	April 20, 2010	9:10 AM	736.52	736.14
April 10, 2010	12:30 PM	742.05	741.86	April 20, 2010	4:20 PM	736.14	735.77
April 10, 2010	10:20 PM	741.86	741.48	April 20, 2010	11:00 PM	735.77	735.39
April 11, 2010	12:45 PM	741.48	741.29	April 21, 2010	10:15 AM	735.39	734.45
April 11, 2010	10:45 PM	741.29	741.19	April 21, 2010	5:00 PM	734.45	732.97
April 12, 2010	10:45 PM	741.19	741.10	April 22, 2010	9:30 AM	732.97	728.00
April 13, 2010	9:20 AM	741.10	740.91	* Time of start of gate operation			

Figure 1 – Recorded River Levels at James Avenue Gauge 2010

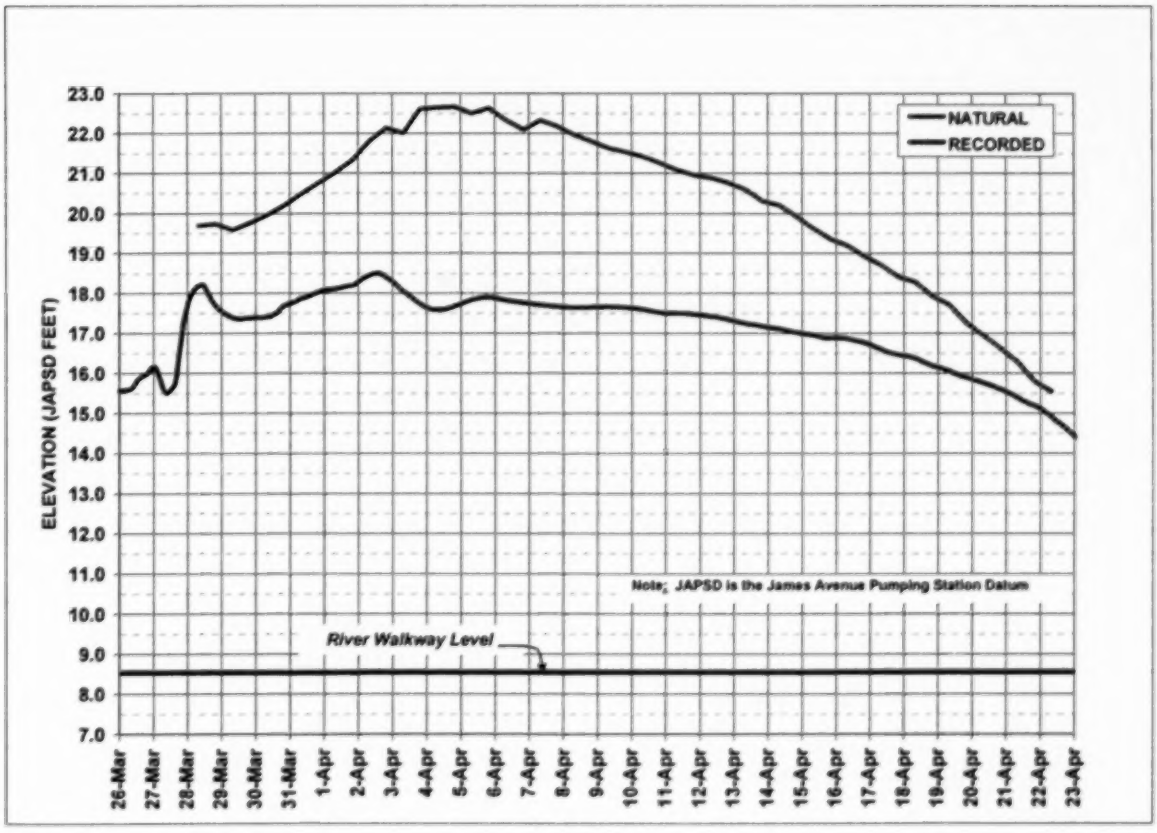


Figure 2 – Recorded and Natural Levels at Floodway Entrance 2010

APPENDIX A

Red River Floodway Rules of Operation

Rules of Operation
Red River Floodway Control Structure

Normal Operation:
1. Maintain natural[1] water levels on the Red River at the entrance to the floodway channel, until the water surface elevation at James Avenue reaches 24.5 feet (7.46 metres), or the river level anywhere along the Red River within the City of Winnipeg reaches two feet below the Flood Protection Level of 27.83 feet (8.48 m).

Major Flood Operation:
2. Once the river levels within Winnipeg reach the limits described in Rule 1, the level in Winnipeg should be held constant while levels south of the control structure continue to rise. Furthermore if forecasts indicate that levels at the entrance to the floodway channel will rise more than two feet (0.6 metres) above natural, the City of Winnipeg must proceed with emergency raising of the dikes and temporary protection measures on the sewer systems in accordance with the flood level forecasts within Winnipeg. The levels in Winnipeg should be permitted to rise as construction proceeds, but not so as to encroach on the freeboard of the dikes or compromise the emergency measures undertaken for protecting the sewer systems. At the same time the Province should consider the possibility of an emergency increase in the height of the floodway embankments and the West Dike. At no time will the water level at the floodway channel's entrance be allowed to rise to a level that infringes on the allowable freeboard on the floodway west embankment (Winnipeg side) and the West Dike.

Extreme Flood Operation:
3. For extreme floods, where the water level at the floodway channel's entrance reaches the maximum level that can be held by the floodway west embankment and the West Dike, the river level must not be permitted to exceed that level. All additional flows must be passed through Winnipeg.

Initial Gate Operation with Ice:
The floodway gates should not be operated until ice on the river is flowing freely, unless flooding in Winnipeg is imminent.

Final drop of Gates:
To minimize bank slumping along the river in Winnipeg and at the same time reduce the probability of sewer backup problems, final gate operations, once the level at the entrance to the floodway channel recedes to elevation 752 feet (229 metres), shall be carried out in consultation with the City of Winnipeg.

Operation of Horn:
The horn at the floodway structure shall only be operated once, before the first gate operation of the year. The horn should be sounded a half-hour before the first gate operation to alert residents that the floodway structure is being put into operation. For ongoing information a 1-800 number should be established that would provide current information of gate operations, potential impacts on water levels, and forecasts for the next few days. The information should also be included on the existing Water Stewardship internet site.

---

[1] The term natural refers to the level that would have occurred in the absence of the flood control works, with the level of urban development in place at the time of the construction of these works.

Emergency Operation to Reduce Sewer Backup in Winnipeg

4(1) This rule defines the circumstances under which the Minister of Water Stewardship ("the Minister") may determine that emergency operation of the floodway is necessary to prevent widespread basement flooding and resulting risk to health and damage to property within the City of Winnipeg.

4(2) This rule applies after the spring crest from snowmelt runoff at Winnipeg, whenever high river levels substantially impair the capacity of Winnipeg's combined sewer system.

4(3) As long as the Department of Water Stewardship ("the Department") forecasts that river levels for the next 10 days will be below 14 feet James Avenue Pumping Station Datum (JAPSD), the Department will not operate the floodway control structure.

4(4) When the Department forecasts that river levels for the next 10 days are expected to rise to 14 feet JAPSD or higher, the Department will prepare a report that describes:

(a) The basis of the Department's river level forecasts and its risk assessment;

(b) The risk of basement flooding in Winnipeg, including the following factors:

(i) The predicted peak river level in the next 10 days;

(ii) The length of time the Department forecasts the river level will be at 14 feet JAPSD or higher;

(iii) The risk of an intense rainfall event in Winnipeg in the next 10 days;

(c) The benefits and costs of floodway operation, including:

(i) The extent of basement flooding and damage to property expected from various combinations of intense rainfall events and high river levels;

(ii) The risk to the health of Winnipeg residents from sewer back-up;

(iii) Economic loss and damage caused by artificial flooding south of the inlet control structure;

(iv) Impacts of operation on fish and wildlife and their habitat and on water quality;

(v) The risks and potential costs of riverbank instability that may be caused by artificial river level changes, both upstream and downstream of the inlet control structure;

(vi) During construction of the floodway expansion, costs and risks associated with any resulting delays of that construction, including the potential average annual expected damages associated with an additional period of risk of a flood event that would exceed the current capacity of the floodway;

(vii) Such other benefits and costs of operation of which the Department is aware at the time of the preparation of the report, excluding benefits associated with recreational or tourism activities or facilities; and

(d) measures that may be taken to mitigate the costs and impacts of the operation under consideration, including:

(i) minimizing the rate at which river levels are changed both upstream and downstream of the floodway inlet control structure;
(ii) providing means to assure fish passage.

4(5) The Department will present a draft of the report prepared under rule 4(4) to the Floodway Operation Review Committee and provide an opportunity for the Committee to provide input, before finalizing the report and making recommendations respecting floodway operation.

4(6) The Department will not recommend operation of the floodway unless the expected benefits of doing so clearly and substantially outweigh the expected costs.

4(7) The Department will present its report and recommendations to the Minister, who, subject to rule 4(8), will make a decision respecting floodway operation based on his or her consideration of the report.

4(8) The Department will not operate the floodway control structure under this rule:

(a) to raise river levels immediately upstream of the control structure to an elevation higher than 760 feet above sea level;

(b) to achieve a river level of less than 9 feet JAPSD; or

(c) except in circumstances of extreme urgency, to lower river levels more than one foot per day.

4(9) The Department will issue a news release announcing a decision to operate the floodway at least 24 hours before commencing operation.

4(10) The Department will ensure every reasonable effort is made to personally notify landowners who may be directly affected by flooding due to floodway operation in advance of the operation.

4(11) The Department will sound the horn at the floodway inlet control structure one-half hour before operation commences.

4(12) The Department will maintain a program of compensation for damages suffered by landowners arising from flooding caused by floodway operation under this rule.

APPENDIX B

Computation of Natural Flows and Levels

Computation of Natural Flows and Levels On the Red and Assiniboine Rivers

Table 2 in the main report lists the natural flows on the Red River below the confluence with the Assiniboine River and on the Assiniboine River at the Forks. This Appendix describes how those flows were determined, and explains how the relationships developed in the Acres 2004 study were applied to compute the natural level at the floodway entrance.

Table B-1 lists the recorded and computed flows and levels for each time step. Columns 1 to 7 list the flows used in computing the natural flows on the Assiniboine River, and columns 8 to 10 list the flows used for computing the natural flows on the Red River.

NATURAL ASSINIBOINE RIVER FLOW

The natural flows on the Assiniboine River are altered by operation of the Shellmouth Dam, the Portage Diversion, and by the presence of dykes along the Assiniboine River.

The Shellmouth Dam can decrease flows below natural levels by adjusting the control gates so that reservoir outflows are lower than the inflows. In this case the reservoir levels rise, and excess water is stored behind the dam.

The Portage Diversion can be used to reduce flows in the lower Assiniboine River by diverting some of the river flow north to Lake Manitoba.

The Assiniboine River dykes were constructed to prevent overflows from the river onto the surrounding lands. Because of the height of the river and the slope of the land much of this overflow did not return to the Assiniboine River. Therefore the dykes have the effect of increasing flows entering Winnipeg on the Assiniboine River during periods of high flow.

Referring to Table B-1, column 1 lists the flow reductions at Winnipeg resulting from storage behind the Shellmouth Dam. It is important to recognize that these flow changes at the dam take some time to reach Winnipeg. The Department uses the Muskingum routing procedure to compute this flow attenuation.

Column 2 shows the flows diverted to Lake Manitoba via the Portage Diversion. Again the flows are routed to Winnipeg to apply the time delay.

Column 3 shows the recorded flows at the hydrometric station at Headingley. These first three columns are summed to determine the total natural flow before applying the natural breakouts that would have occurred if the dykes were not in place.

Column 4 lists the computed breakouts that would have occurred at those flows if the dykes had not been constructed.

Column 5 lists the computed natural flows at Headingley. These are computed by adding the three adjustments to the recorded flows at Headingley.

There is some additional local inflow entering the Assiniboine River between Headingley and the Forks. Most of this flow is recorded on Sturgeon Creek. In column 6 the recorded flows on Sturgeon Creek are increased to include unmeasured local inflows.

Finally columns 5 and 6 are added together to give the computed natural flows of the Assiniboine River at the Forks, as listed in column 7.

NATURAL RED RIVER FLOW

On the Red River the primary flow adjustment is caused by the Red River Floodway. During periods of extensive flooding there can also be a flow change resulting from changes in the storage of floodwaters on the land, but as long as flood levels at the floodway entrance are held at natural that change would be negligible.

Column 8 lists the recorded flows in the floodway channel, and column 9 shows the recorded flows at James Avenue. Column 10 sums the flows in those two columns and adds the three flow adjustments on the Assiniboine River to give the total natural flow on the Red River at James Avenue, which is downstream of the Forks.

NATURAL RIVER LEVELS AT THE FLOODWAY INLET

Table B-2 is a reproduction of Table 4-7 from the Acres report *"Re-Computation of Natural Water Levels at the Floodway Inlet (Final Report), April 2004"*. The table provides natural elevations at the inlet based upon the relative contribution of natural flow at the Forks from the Red and Assiniboine Rivers. The *combined* flow is represented by the values in the left-hand column entitled Red River at James Avenue. The Assiniboine River Contribution amount is shown across the top and is the flow in the Assiniboine River at the Forks.

The natural water level at the inlet can vary by a few feet dependent upon the amount of flow coming from the Assiniboine River (Assiniboine River Contribution). This phenomenon is referred to as a variable backwater effect.

This concept can be illustrated by using the example of 100,000 cfs flow for the Red River at James Avenue in various combinations of Red and Assiniboine River flows. One combination could have 95,000 cfs as Red River flow upstream of the Forks and 5,000 cfs as Assiniboine River Contribution; this combination results in a level at the inlet of 765.6 feet as shown in Table B-2. Similarly, another combination, while still yielding a total James Avenue flow of 100,000 cfs, could be 70,000 cfs as Red River flow upstream of the Forks and 30,000 cfs as Assiniboine River Contribution; the resulting inlet level would be 762.9 feet. The difference in the inlet water elevation between these two flow combinations is 2.7 feet, with the lower elevation occurring when there is relatively more flow on the Assiniboine River.

Natural levels are determined by using the natural Red River flows at James Avenue listed in column 10 of Table B-1, and the natural Assiniboine River flows listed in column 7 of Table B-1 and interpolating between the values listed in Table B-2 to determine the natural levels. These natural levels are listed in column 13 of Table B-1. For comparison, column 14 of Table B-1

lists the recorded levels at the floodway inlet (station 05OC026). Similar levels for James Avenue in Winnipeg are provided in columns 11 and 12.

Table B-1 Spring 2010 Flows and Levels

Column =>	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Assiniboine Flows							Red River Flows						
	Shellmouth Flow Changes (Routed to Headingley)	Portage Diversion flow (Routed to Headingley)	Actual Assiniboine R. flow at Headingley	Natural breakouts from river	Natural Assiniboine River flow at Headingley	Sturgeon Cr. Flow plus other local inflows	Natural Assiniboine R. flow into Red River	Red River Floodway flow	Red River flow at James Ave.	Natural Red River flow at James Avenue	Natural Water Level at James Ave (feet)	Recorded Water Level at James Ave (feet)	Natural water level on Red R. at Floodway Inlet (feet)	Recorded Water level on Red R. at Floodway Inlet (feet)
Date / Time	*Recorded*	*Recorded*	*Recorded*	*Computed*	*=1+2+3-4*	*Rec. & Est.*	*=5+6*	*Recorded*	*Recorded*	*=1+2-4+8+9*	*Computed*	*Recorded*	*Computed*	*Recorded*
28-Mar-2010 8:00 AM	-225	0	2,330	0	2,105	173	2,278	6,234	54,320	60,329	19.70	18.18	756.49	754.64
28-Mar-2010 8:00 PM	-225	0	2,207	0	1,982	191	2,173	8,344	52,352	60,471	19.74	17.69	756.55	755.97
29-Mar-2010 8:00 AM	-162	0	2,269	0	2,107	189	2,296	8,724	51,314	59,877	19.58	17.39	756.35	756.11
29-Mar-2010 8:00 PM	-132	0	2,291	0	2,159	196	2,356	9,320	51,369	60,557	19.76	17.38	756.54	756.25
30-Mar-2010 8:00 AM	-102	0	2,418	0	2,316	217	2,534	9,915	51,520	61,333	19.96	17.41	756.73	756.54
30-Mar-2010 8:00 PM	-74	0	2,571	0	2,497	224	2,722	9,786	52,644	62,355	20.19	17.68	756.99	756.47
31-Mar-2010 8:00 AM	-46	0	2,878	0	2,832	509	3,340	10,188	53,522	63,664	20.48	17.88	757.26	756.64
31-Mar-2010 8:00 PM	-20	0	3,027	0	3,007	422	3,429	10,560	54,333	64,872	20.75	18.03	757.60	756.83
01-Apr-2010 8:00 AM	6	0	3,558	0	3,564	273	3,837	11,236	54,811	66,053	21.01	18.11	757.86	757.10
01-Apr-2010 8:00 PM	28	0	3,519	0	3,547	255	3,802	11,972	55,258	67,258	21.31	18.20	758.22	757.41
02-Apr-2010 8:00 AM	50	0	3,246	0	3,296	303	3,599	12,755	56,370	69,175	21.79	18.45	758.81	757.75
02-Apr-2010 8:00 PM	69	0	2,608	0	2,677	301	2,978	14,449	56,124	70,642	22.13	18.39	759.34	758.44
03-Apr-2010 8:00 AM	100	0	2,148	0	2,248	334	2,582	15,354	54,551	70,004	22.00	18.04	759.24	758.75
03-Apr-2010 8:00 PM	124	3,635	1,962	0	5,720	340	6,060	16,101	53,183	73,042	22.61	17.73	759.48	759.01
04-Apr-2010 8:00 AM	147	4,250	1,892	0	6,289	294	6,583	16,119	52,709	73,224	22.64	17.60	759.45	759.01
04-Apr-2010 8:00 PM	158	4,250	1,860	0	6,268	281	6,549	15,867	53,025	73,300	22.66	17.68	759.48	758.92
05-Apr-2010 8:00 AM	169	3,069	1,709	0	4,947	268	5,216	15,558	53,699	72,495	22.50	17.84	759.46	758.83
05-Apr-2010 8:00 PM	180	3,145	1,583	0	4,909	244	5,153	15,890	53,959	73,174	22.63	17.90	759.66	758.91
06-Apr-2010 8:00 AM	186	1,861	1,419	0	3,465	232	3,697	15,950	53,627	71,624	22.32	17.83	759.48	758.95
06-Apr-2010 8:00 PM	194	903	1,308	0	2,405	211	2,616	15,944	53,367	70,408	22.08	17.77	759.34	758.91
07-Apr-2010 8:00 AM	201	2,449	1,268	0	3,918	234	4,152	15,831	53,146	71,628	22.33	17.72	759.41	758.85
07-Apr-2010 8:00 PM	216	2,334	1,265	0	3,815	225	4,039	15,692	52,618	70,860	22.17	17.67	759.21	758.82
08-Apr-2010 8:00 AM	220	2,143	1,285	0	3,648	188	3,836	15,376	52,077	69,816	21.95	17.65	758.96	758.67
08-Apr-2010 8:00 AM	220	2,143	1,285	0	3,648	188	3,836	15,376	52,077	69,816	21.95	17.65	758.96	758.67
09-Apr-2010 8:00 AM	249	2,183	1,263	0	3,695	176	3,872	14,376	51,681	68,489	21.62	17.67	758.56	758.24
09-Apr-2010 8:00 PM	272	2,392	1,266	0	3,929	173	4,102	13,922	51,522	68,107	21.53	17.65	758.41	758.08
10-Apr-2010 8:00 AM	294	2,401	1,261	0	3,956	160	4,116	13,616	51,340	67,651	21.41	17.60	758.28	757.95
10-Apr-2010 8:00 PM	326	2,406	1,225	0	3,956	160	4,116	13,227	51,061	67,020	21.26	17.52	758.09	757.76
11-Apr-2010 8:00 AM	357	2,415	1,196	0	3,967	157	4,124	12,558	51,000	66,330	21.08	17.51	757.89	757.49
11-Apr-2010 8:00 PM	399	2,423	1,193	0	4,015	145	4,160	12,099	50,891	65,812	20.96	17.48	757.74	757.25

Table B-1 Spring 2010 Flows and Levels *continued*

Column =>	1	2	3	4	5	6	7	8	9	10	11	12	13	14
			Assiniboine Flows					Red River Flows						
	Shellmouth Flow Changes (Routed to Headingley)	Portage Diversion flow (Routed to Headingley)	Actual Assiniboine R. flow at Headingley	Natural breakouts from river	Natural Assiniboine River flow at Headingley	Sturgeon Cr. Flow plus other local inflows	Natural Assiniboine R. flow into Red River	Red River Floodway flow	Red River flow at James Ave.	Natural Red River flow at James Avenue	Natural Water Level at James Ave (feet)	Recorded Water Level at James Ave (feet)	Natural water level on Red R. at Floodway Inlet (feet)	Recorded Water level on Red R. at Floodway Inlet (feet)
Date / Time	*Recorded*	*Recorded*	*Recorded*	*Computed*	*=1+2+3-4*	*Rec. & Est.*	*=5+6*	*Recorded*	*Recorded*	*=1+2-4+8+9*	*Computed*	*Recorded*	*Computed*	*Recorded*
12-Apr-2010 8:00 AM	441	2,692	1,194	0	4,327	143	4,471	11,670	50,697	65,500	20.89	17.42	757.59	757.13
12-Apr-2010 8:00 PM	492	2,717	1,169	0	4,377	141	4,518	11,329	50,405	64,943	20.77	17.34	757.42	756.94
13-Apr-2010 8:00 AM	542	2,719	1,175	0	4,437	140	4,576	10,889	50,041	64,192	20.60	17.25	757.19	756.72
13-Apr-2010 8:00 PM	601	2,206	1,205	0	4,012	138	4,149	10,267	49,847	62,920	20.32	17.19	756.90	756.45
14-Apr-2010 8:00 AM	659	2,443	1,174	0	4,275	137	4,412	9,760	49,531	62,393	20.20	17.11	756.70	756.19
14-Apr-2010 8:00 PM	726	2,166	1,155	0	4,047	137	4,184	9,133	49,180	61,204	19.92	17.02	756.40	755.90
15-Apr-2010 8:00 AM	792	1,932	1,164	0	3,889	136	4,025	8,501	48,797	60,023	19.62	16.95	756.08	755.63
15-Apr-2010 8:00 PM	864	1,929	1,160	0	3,953	135	4,088	7,790	48,415	58,997	19.36	16.89	755.75	755.20
16-Apr-2010 8:00 AM	935	1,951	1,154	0	4,041	135	4,176	7,282	48,190	58,358	19.19	16.86	755.53	754.92
16-Apr-2010 8:00 PM	1009	1,706	1,170	0	3,885	135	4,020	6,806	47,756	57,277	18.93	16.76	755.22	754.63
17-Apr-2010 8:00 AM	1083	1,731	1,201	0	4,015	134	4,149	6,457	47,060	56,332	18.71	16.59	754.89	754.41
17-Apr-2010 8:00 PM	1154	1,447	1,232	0	3,833	134	3,967	5,853	46,562	55,015	18.41	16.47	754.51	754.05
18-Apr-2010 8:00 AM	1224	1,713	1,219	0	4,156	134	4,291	5,329	46,181	54,447	18.28	16.37	754.27	753.73
18-Apr-2010 8:00 PM	1287	1,452	1,211	0	3,949	134	4,084	4,731	45,459	52,929	17.93	16.19	753.83	753.39
19-Apr-2010 8:00 AM	1347	1,738	1,161	0	4,246	134	4,381	4,122	44,921	52,128	17.71	16.06	753.51	753.06
19-Apr-2010 8:00 PM	1398	1,521	1,156	0	4,075	134	4,209	3,283	44,265	50,467	17.26	15.89	753.02	752.60
20-Apr-2010 8:00 AM	1449	1,522	1,190	0	4,161	134	4,296	2,583	43,727	49,281	16.95	15.76	752.60	752.19
20-Apr-2010 8:00 PM	1486	1,559	1,186	0	4,231	134	4,366	1,854	43,097	47,996	16.62	15.60	752.14	751.72
21-Apr-2010 8:00 AM	1522	1,586	1,163	0	4,271	134	4,405	1,281	42,257	46,646	16.29	15.39	751.66	751.24
21-Apr-2010 8:00 PM	1544	1,706	1,159	0	4,410	134	4,544	0	41,447	44,698	15.80	15.19	750.95	750.50
22-Apr-2010 8:00 AM	1566	1,725	1,164	0	4,454	134	4,589	0	40,389	43,680	15.54	14.90	750.58	749.99

Table B-2 Red River Floodway Inlet Natural Rating Table

RED RIVER AT JAMES AVENUE (cfs)	ASSINIBOINE RIVER CONTRIBUTION (cfs)										
cfs	0	5,000	10,000	15,000	20,000	25,000	30,000	35,000	40,000	45,000	50,000
20,000	742.1	740.4	738.7	737.4							
30,000	746.6	745.2	743.9	742.6	741.5						
40,000	750.4	749.2	748.0	746.9	745.8	744.9					
50,000	753.8	752.7	751.7	750.7	749.7	748.8	747.9				
60,000	756.8	755.9	754.9	754.0	753.1	752.2	751.4				
70,000	759.7	758.8	758.0	757.1	756.3	755.5	754.7				
80,000	762.4	761.6	760.8	760.1	759.3	758.5	757.8				
90,000		763.9	763.2	762.6	761.9	761.2	760.6	759.9			
100,000		765.6	765.3	764.8	764.1	763.5	762.9	762.3			
110,000		766.7	766.3	765.9	765.5	765.2	764.7	764.2			
120,000		767.6	767.5	767.2	766.8	766.5	766.1	765.7	765.4		
130,000		768.5	768.2	768.0	767.7	767.5	767.3	767.0	766.6		
140,000			768.7	768.7	768.6	768.4	768.1	767.9	767.6	767.4	
150,000			769.1	769.0	768.8	768.7	768.6	768.5	768.5	768.3	
160,000			769.6	769.4	769.2	769.1	768.9	768.8	768.7	768.5	768.5
170,000			770.1	769.9	769.8	769.6	769.5	769.3	769.2	769.0	768.8
180,000			770.5	770.4	770.3	770.2	770.0	769.9	769.7	769.5	769.4
190,000				770.5	770.5	770.5	770.5	770.3	770.2	770.1	769.9
200,000				770.7	770.6	770.6	770.5	770.5	770.5	770.5	770.5
210,000				770.9	770.8	770.7	770.7	770.6	770.6	770.5	770.5
220,000				771.1	771.0	770.9	770.8	770.7	770.7	770.6	770.5
230,000				771.2	771.2	771.1	771.0	770.9	770.8	770.7	770.7
240,000					771.5	771.4	771.3	771.2	771.1	771.0	770.9
250,000					771.8	771.7	771.6	771.6	771.5	771.4	771.3
260,000					772.1	772.0	772.0	771.9	771.8	771.7	771.6
270,000					772.4	772.4	772.3	772.2	772.1	772.1	772.0
280,000					772.8	772.7	772.6	772.5	772.5	772.4	772.3
290,000					773.1	773.0	772.9	772.8	772.8	772.7	772.6
300,000					773.3	773.3	773.2	773.1	773.1	773.0	772.9

Note: Open water conditions under steady state (no ice)